

UNIVERSITI SAINS MALAYSIA

**Peperiksaan Semester Pertama
Sidang Akademik 1997/98**

September/Oktober 1997

IKK 304/2 - OPERASI UNIT II

Masa : [3 jam]

Sila pastikan bahawa kertas soalan ini mengandungi DUABELAS (12) mukasurat yang bercetak termasuk Lampiran sebelum anda memulakan peperiksaan ini.

Jawab sebarang TIGA (3) soalan. Semua soalan mesti dijawab di dalam Bahasa Malaysia.

1. (a) Bincangkan tentang pemindahan haba konduksi menerusi plat rata, silinder panjang, dan sfera.

(20 markah)

- (b) Satu penukar haba dwipaip digunakan untuk meningkatkan suhu cecair A dari 408 hingga 427°F. Garispusat paip dalaman yang nipis ialah 6.35 in. Cecair A mengalir di dalam paip dalaman manakala cecair B mengalir di dalam anulus. Suhu cecair B yang mengalir secara arus lawan dengan cecair A diturun dari 551 hingga 526°F. Sifat-sifat kedua-dua cecair adalah seperti berikut:

Cecair A	Cecair B
$m = 143\,400 \text{ lb/h}$	
$\rho = 46.8 \text{ lb/ft}^3$	$\rho = 51.5 \text{ lb/ft}^3$
$C_p = 0.68 \text{ Btu/lb-}^\circ\text{F}$	$C_p = 0.75 \text{ Btu/lb-}^\circ\text{F}$
$k = 0.075 \text{ Btu/ft-h-}^\circ\text{F}$	$k = 0.075 \text{ Btu/ft-h-}^\circ\text{F}$
$\mu = 0.00164 \text{ lb/ft-s}$	

Dengan mengabaikan rintangan dan kesan kepada kelikatan daripada dinding paip, dan $h_o = 340 \text{ Btu/ft}^2\text{-h-}^\circ\text{F}$, kirakan

- (i) kadar haba yang dipindah
- (ii) kadar aliran jisim cecair B

- (iii) koefisien pemindahan haba untuk cecair A
- (iv) panjang paip dalaman yang diperlukan

(80 markah)

2. (a) Bincangkan tentang pemindahan haba kondensasi.

(15 markah)

- (b) Air pada kadar 3.8 kg/s dipanaskan dari 37.8°C hingga 54.5°C di dalam satu penukar haba petala-dan-tiub. Di sisi petala, satu laluan digunakan dengan air sebagai bendalir pemanasan yang memasuki pada 93.4°C. Koefisien pemindahan haba keseluruhan ialah 1420 W/m²-°C dan halaju air di dalam tiub nipis yang bergarispusat 1.9 cm ialah 0.37 m/s. Oleh kerana ruang terhad, panjang tiub tidak boleh melebihi 2.44 m. Jika aliran adalah arus lawan, kirakan

- (i) kadar pemindahan haba, kW
- (ii) suhu air panas keluar
- (iii) jumlah luas permukaan

- (iv) jumlah luas keratan-rentas tiub
- (v) jumlah bilangan tiub
- (vi) bilangan laluan tiub
- (vii) panjang tiub selaluan

$$\rho \text{ (air)} = 1000 \text{ kg/m}^3, C_p \text{ (air)} = 4.18 \text{ kJ/kg-}^\circ\text{C}$$

(85 markah)

3. (a) Huraikan sifat-sifat satu kondenser dengan bantuan profil suhu dan imbangan haba.

(20 markah)

- (b) Ceritakan tentang pendidihan cecair tepu.

(30 markah)

(c) Apakah yang anda boleh jelaskan tentang perkara-perkara berikut berkaitan dengan sinaran haba?

- (i) faktor bentuk, F
- (ii) kesan rumah kaca (green house effect)

(50 markah)

4. (a) (i) Jelaskan tentang perkara-perkara yang mempengaruhi pemilihan sesuatu penyejat.

- (ii) Bagaimana anda dapat menentukan saiz sesuatu penyejat.

(50 markah)

(b) Suatu filamen lampu tungsten dipanaskan sehingga suhu 2500 K. Jika filamen itu boleh dianggap sebagai suatu jasad hitam,

- (i) kira fluks sinaran haba maksimum dari filamen tersebut.

- (ii) tentukan pecahan dari tenaga yang terjana yang boleh dikaitkan dengan julat cahaya boleh dilihat. (iaitu dari $\lambda = 0.4 \mu\text{m}$ sehingga $\lambda = 0.7 \mu\text{m}$).

Perhatian:

Anda boleh menggunakan Lampiran 6 untuk membantu dalam pengiraan.

$$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$$

(50 markah)

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CONVERSION FACTORS AND CONSTANTS OF NATURE

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To convert from	To	Multiply by†
acre	ft ²	43,560*
	m ²	4,046.85
atm	N/m ²	1.01325* × 10 ⁵
	lb _f /in. ²	14.696
Avogadro number	particles/g mol	6.022169 × 10 ²³
barrel (petroleum)	ft ³	5.6146
	gal (U.S.)	42*
	m ³	0.15899
bar	N/m ²	1* × 10 ⁵
	lb _f /in. ²	14.504
Boltzmann constant	J/K	1.380622 × 10 ⁻²³
Btu	cal _{IT}	251.996
	ft-lb _f	778.17
	J	1,055.06
	kWh	2.9307 × 10 ⁻⁴
Btu/lb	cal _{IT} /g	0.55556
Btu/lb-°F	cal _{IT} /g-°C	1*
Btu/ft ² -h	W/m ²	3.1546
Btu/ft ² -h-°F	W/m ² -°C	5.6783
Btu-ft/ft ² -h-°F	W-m/m ² -°C	1.73073
cal _{IT}	Btu	3.9683 × 10 ⁻³
	ft-lb _f	3.0873
	J	4.1868*
cal	J	4.184*
cm	in.	0.39370
	ft	0.0328084
cm ³	ft ³	3.531467 × 10 ⁻⁵
	gal (U.S.)	2.64172 × 10 ⁻⁴
cP (centipoise)	kg/m-s	1* × 10 ⁻³
	lb/ft-h	2.4191
	lb/ft-s	6.7197 × 10 ⁻⁴
cSt (centistoke)	m ² /s	1* × 10 ⁻⁶
faraday	C/g mol	9.648670 × 10 ⁴
ft	m	0.3048*
ft-lb _f	Btu	1.2851 × 10 ⁻³
	cal _{IT}	0.32383
	J	1.35582
ft-lb _f /s	Btu/h	4.6262
	hp	1.81818 × 10 ⁻³
ft ² /h	m ² /s	2.581 × 10 ⁻⁵
	cm ² /s	0.2581
ft ³	cm ³	2.8316839 × 10 ⁴
	gal (U.S.)	7.48052
	l	28.31684
ft ³ -atm	Btu	2.71948
	cal _{IT}	685.29
	J	2.8692 × 10 ³
ft ³ /s	gal (U.S.)/min	448.83
gal (U.S.)	ft ³	0.13368
	in. ³	231*
gravitational constant	N-m ² /kg ²	6.673 × 10 ⁻¹¹
gravity acceleration, standard	m/s ²	9.80665*
h	min	60*
	s	3,600*
hp	Btu/h	2,544.43
	kW	0.74570
in.	cm	2.54*
in. ³	cm ³	16.3871
J	erg	1* × 10 ⁷
	ft-lb _f	0.73756
kg	lb	2.20462
kWh	Btu	3,412.1
l	m ³	1* × 10 ⁻³
lb	kg	0.45359237*
lb/ft ³	kg/m ³	16.018
	g/cm ³	0.016018
lb _f /in. ²	N/m ²	6.89473 × 10 ³
lb mol/ft ² -h	kg mol/m ² -s	1.3652 × 10 ⁻³
	g mol/cm ² -s	1.3652 × 10 ⁻⁴
light, speed of	m/s	2.997925 × 10 ⁸
m	ft	3.280840
	in.	39.3701
m ³	ft ³	35.3147
	gal (U.S.)	264.17
N	dyn	1* × 10 ⁵
	lb _f	0.22481
N/m ²	lb _f /in. ²	1.4498 × 10 ⁻⁴
Planck constant	J-s	6.626196 × 10 ⁻³⁴
proof (U.S.)	percent alcohol by volume	0.5
ton (long)	kg	1,016
	lb	2,240*
ton (short)	lb	2,000*
ton (metric)	kg	1,000*
	lb	2,204.6
yd	ft	3*
	m	0.9144*

† Values that end in * are exact, by definition.

UK-304/2

PROPERTIES OF LIQUID WATER

Temperature T , °F	Viscosity† μ' , cP	Thermal conductivity‡ k , Btu/ft-h-°F	Density§ ρ , lb/ft ³	$\psi_f = \left(\frac{k^3 \rho^2 g}{\mu^2} \right)^{1/3}$
32	1.794	0.320	62.42	1,410
40	1.546	0.326	62.43	1,590
50	1.310	0.333	62.42	1,810
60	1.129	0.340	62.37	2,050
70	0.982	0.346	62.30	2,290
80	0.862	0.352	62.22	2,530
90	0.764	0.358	62.11	2,780
100	0.682	0.362	62.00	3,020
120	0.559	0.371	61.71	3,530
140	0.470	0.378	61.38	4,030
160	0.401	0.384	61.00	4,530
180	0.347	0.388	60.58	5,020
200	0.305	0.392	60.13	5,500
220	0.270	0.394	59.63	5,960
240	0.242	0.396	59.10	6,420
260	0.218	0.396	58.53	6,830
280	0.199	0.396	57.94	7,210
300	0.185	0.396	57.31	7,510

† From *International Critical Tables*, vol. 5, McGraw-Hill Book Company, New York, 1929, p. 10.

‡ From E. Schmidt and W. Sellschopp, *Forsch. Geb. Ingenieurw.*, 3:277 (1932).

§ Calculated from J. H. Keenan and F. G. Keyes, *Thermodynamic Properties of Steam*, John Wiley & Sons., Inc., New York, 1937.

PROPERTIES OF SATURATED STEAM AND WATER†

IKK304/2

Temperature T , °F	Vapor pressure p_A , lb _f /in. ²	Specific volume, ft ³ /lb		Enthalpy, Btu/lb		
		Liquid v_x	Saturated vapor v_y	Liquid H_x	Vaporization λ	Saturated vapor H_y
32	0.08859	0.016022	3305	0	1075.4	1075.4
35	0.09992	0.016021	2948	3.00	1073.7	1076.7
40	0.12166	0.016020	2445	8.02	1070.9	1078.9
45	0.14748	0.016021	2037	13.04	1068.1	1081.1
50	0.17803	0.016024	1704.2	18.06	1065.2	1083.3
55	0.2140	0.016029	1431.4	23.07	1062.4	1085.5
60	0.2563	0.016035	1206.9	28.08	1059.6	1087.7
65	0.3057	0.016042	1021.5	33.09	1056.8	1089.9
70	0.3632	0.016051	867.7	38.09	1054.0	1092.0
75	0.4300	0.016061	739.7	43.09	1051.1	1094.2
80	0.5073	0.016073	632.8	48.09	1048.3	1096.4
85	0.5964	0.016085	543.1	53.08	1045.5	1098.6
90	0.6988	0.016099	467.7	58.07	1042.7	1100.7
95	0.8162	0.016114	404.0	63.06	1039.8	1102.9
100	0.9503	0.016130	350.0	68.05	1037.0	1105.0
110	1.2763	0.016166	265.1	78.02	1031.4	1109.3
120	1.6945	0.016205	203.0	88.00	1025.5	1113.5
130	2.225	0.016247	157.17	97.98	1019.8	1117.8
140	2.892	0.016293	122.88	107.96	1014.0	1121.9
150	3.722	0.016343	96.99	117.96	1008.1	1126.1
160	4.745	0.016395	77.23	127.96	1002.2	1130.1
170	5.996	0.016450	62.02	137.97	996.2	1134.2
180	7.515	0.016509	50.20	147.99	990.2	1138.2
190	9.343	0.016570	40.95	158.03	984.1	1142.1
200	11.529	0.016634	33.63	168.07	977.9	1145.9
210	14.125	0.016702	27.82	178.14	971.6	1149.7
212	14.698	0.016716	26.80	180.16	970.3	1150.5
220	17.188	0.016772	23.15	188.22	965.3	1153.5
230	20.78	0.016845	19.386	198.32	958.8	1157.1
240	24.97	0.016922	16.327	208.44	952.3	1160.7
250	29.82	0.017001	13.826	218.59	945.6	1164.2
260	35.42	0.017084	11.768	228.76	938.8	1167.6
270	41.85	0.017170	10.066	238.95	932.0	1170.9
280	49.18	0.017259	8.650	249.18	924.9	1174.1
290	57.53	0.017352	7.467	259.44	917.8	1177.2
300	66.98	0.017448	6.472	269.73	910.4	1180.2
310	77.64	0.017548	5.632	280.06	903.0	1183.0
320	89.60	0.017652	4.919	290.43	895.3	1185.8
340	117.93	0.017872	3.792	311.30	879.5	1190.8
350	134.53	0.017988	3.346	321.80	871.3	1193.1
360	152.92	0.018108	2.961	332.35	862.9	1195.2
370	173.23	0.018233	2.628	342.96	854.2	1197.2
380	195.60	0.018363	2.339	353.62	845.4	1199.0
390	220.2	0.018498	2.087	364.34	836.2	1200.6
400	247.1	0.018638	1.8661	375.12	826.8	1202.0
410	276.5	0.018784	1.6726	385.97	817.2	1203.1
420	308.5	0.018936	1.5024	396.89	807.2	1204.1
430	343.3	0.019094	1.3521	407.89	796.9	1204.8
440	381.2	0.019260	1.2192	418.98	786.3	1205.3
450	422.1	0.019433	1.1011	430.2	775.4	1205.6

† Abstracted from *Steam Tables*, by Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and Joan G. Moore, John Wiley & Sons, New York, 1969, with the permission of the publisher.

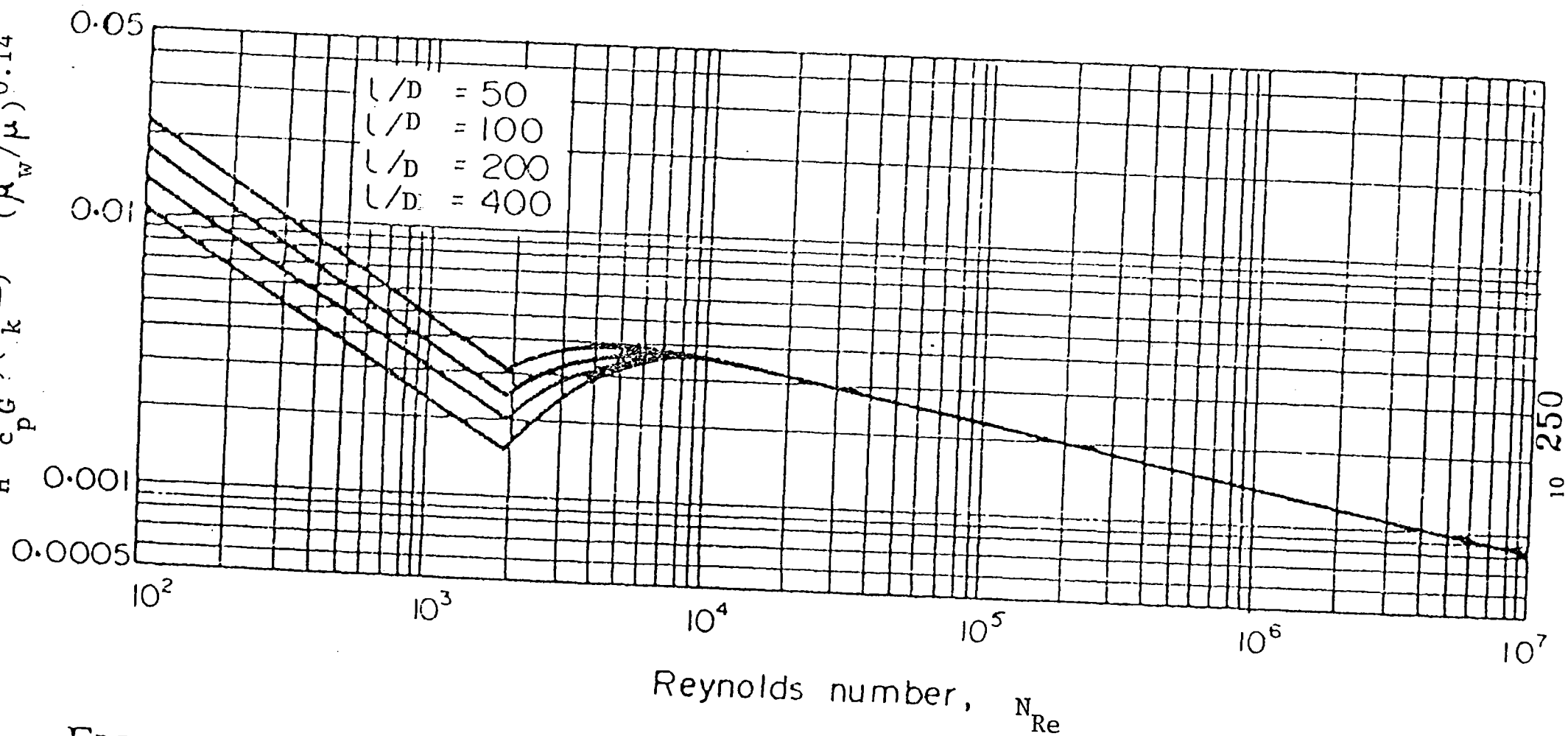


FIG. Effect of length:diameter ratio on heat transfer coefficient.

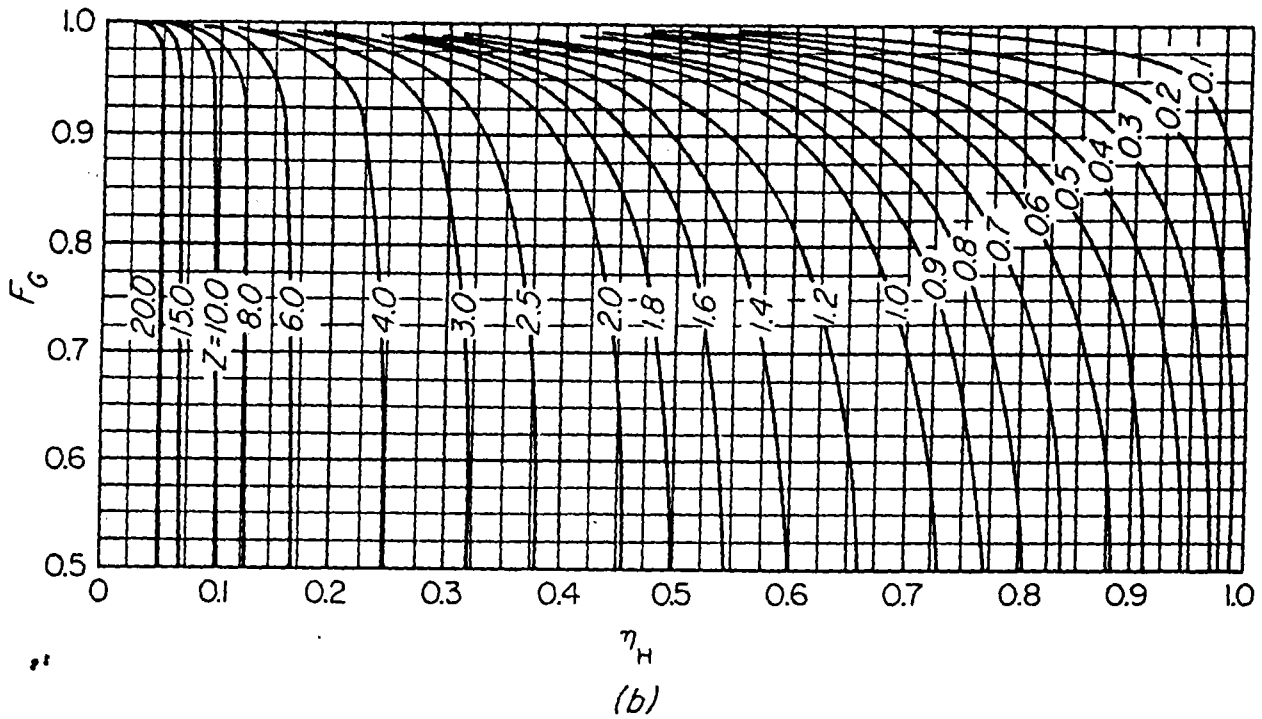
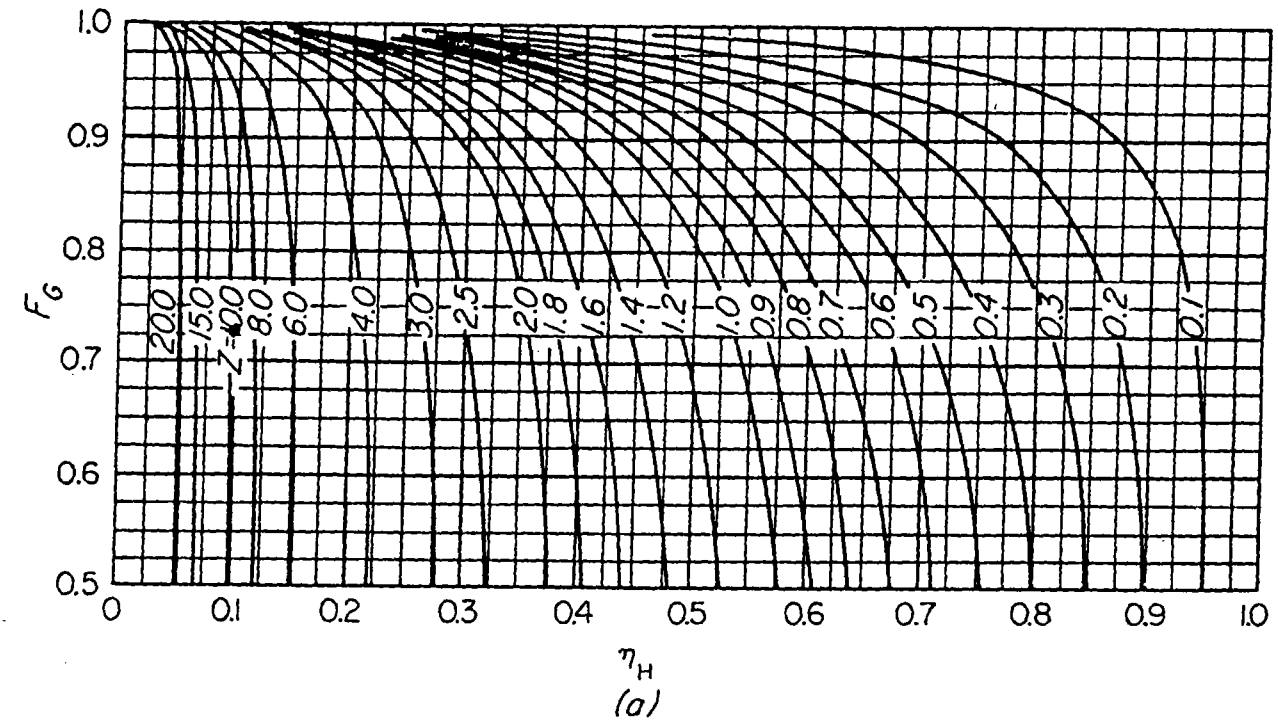


Figure 15-5 Correction of LMTD: (a) 1-2 exchangers; (b) 2-4 exchangers. [From R. A. Bowman, A. C. Mueller, and W. M. Nagle, *Trans. ASME*, 62:283 (1940). Courtesy of American Society of Mechanical Engineers.]

Table 12-1 Blackbody radiation functions

$\frac{E_{b\lambda}}{T^5}$				$\frac{E_{b\lambda}}{T^5}$			
λT	λT	W	$f_{0-\lambda}(T)$	λT	λT	W	$f_{0-\lambda}(T)$
$\mu\text{m} \cdot \text{K}$	$\mu\text{m} \cdot ^\circ\text{R}$	$\frac{\text{m}^2 \cdot \text{K}^5 \cdot \mu\text{m}}{\times 10^{11}}$		$\mu\text{m} \cdot \text{K}$	$\mu\text{m} \cdot ^\circ\text{R}$	$\frac{\text{m}^2 \cdot \text{K}^5 \cdot \mu\text{m}}{\times 10^{11}}$	
555.6	1,000	0.400×10^{-5}	0.00000	5,777.8	10,400	0.52517	0.71806
666.7	1,200	0.120×10^{-3}	0.00000	5,888.9	10,600	0.50261	0.72813
777.8	1,400	0.00122	0.00000	6,000.0	10,800	0.48107	0.73777
888.9	1,600	0.00630	0.00007	6,111.1	11,000	0.46051	0.74700
1,000.0	1,800	0.02111	0.00032	6,222.2	11,200	0.44089	0.75583
1,111.1	2,000	0.05254	0.00101	6,333.3	11,400	0.42218	0.76429
1,222.2	2,200	0.10587	0.00252	6,444.4	11,600	0.40434	0.77238
1,333.3	2,400	0.18275	0.00531	6,555.6	11,800	0.38732	0.78014
1,444.4	2,600	0.28091	0.00983	6,666.7	12,000	0.37111	0.78757
1,555.6	2,800	0.39505	0.01643	6,777.8	12,200	0.35565	0.79469
1,666.7	3,000	0.51841	0.02537	6,888.9	12,400	0.34091	0.80152
1,777.8	3,200	0.64404	0.03677	7,000.0	12,600	0.32687	0.80806
1,888.9	3,400	0.76578	0.05059	7,111.1	12,800	0.31348	0.81433
2,000.0	3,600	0.87878	0.06672	7,222.2	13,000	0.30071	0.82035
2,111.1	3,800	0.97963	0.08496	7,333.3	13,200	0.28855	0.82612
2,222.2	4,000	1.0663	0.10503	7,444.4	13,400	0.27695	0.83166
2,333.3	4,200	1.1378	0.12665	7,555.6	13,600	0.26589	0.83698
2,444.4	4,400	1.1942	0.14953	7,666.7	13,800	0.25534	0.84209
2,555.6	4,600	1.2361	0.17337	7,777.8	14,000	0.24527	0.84699
2,666.7	4,800	1.2645	0.19789	7,888.9	14,200	0.23567	0.85171
2,777.8	5,000	1.2808	0.22285	8,000.0	14,400	0.22651	0.85624
2,888.9	5,200	1.2864	0.24803	8,111.1	14,600	0.21777	0.86059
3,000.0	5,400	1.2827	0.27322	8,222.2	14,800	0.20942	0.86477
3,111.1	5,600	1.2713	0.29825	8,333.3	15,000	0.20145	0.86880
3,222.2	5,800	1.2532	0.32300	8,588.9	16,000	0.16662	0.88677
3,333.3	6,000	1.2299	0.34734	9,444.4	17,000	0.13877	0.90168
3,444.4	6,200	1.2023	0.37118	10,000.0	18,000	0.11635	0.91414
3,555.6	6,400	1.1714	0.39445	10,555.6	19,000	0.09817	0.92462
3,666.7	6,600	1.1380	0.41708	11,111.1	20,000	0.08334	0.93349
3,777.8	6,800	1.1029	0.43905	11,666.7	21,000	0.07116	0.94104
3,888.9	7,000	1.0665	0.46031	12,222.2	22,000	0.06109	0.94751
4,000.0	7,200	1.0295	0.48085	12,777.8	23,000	0.05272	0.95307
4,111.1	7,400	0.99221	0.50066	13,333.3	24,000	0.04572	0.95788
4,222.2	7,600	0.95499	0.51974	13,888.9	25,000	0.03982	0.96207
4,333.3	7,800	0.91813	0.53809	14,444.4	26,000	0.03484	0.96572
4,444.4	8,000	0.88184	0.55573	15,000.0	27,000	0.03061	0.96892
4,555.6	8,200	0.84629	0.57267	15,555.6	28,000	0.02699	0.97174
4,666.7	8,400	0.81163	0.58891	16,111.1	29,000	0.02389	0.97423
4,777.8	8,600	0.77796	0.60449	16,666.7	30,000	0.02122	0.97644
4,888.9	8,800	0.74534	0.61941	22,222.2	40,000	0.00758	0.98915
5,000.0	9,000	0.71383	0.63371	27,777.8	50,000	0.00333	0.99414
5,111.1	9,200	0.68346	0.64740	33,333.3	60,000	0.00168	0.99649
5,222.2	9,400	0.65423	0.66051	38,888.9	70,000	0.940×10^{-3}	0.99773
5,333.3	9,600	0.62617	0.67305	44,444.4	80,000	0.564×10^{-3}	0.99845
5,444.4	9,800	0.59925	0.68506	50,000.0	90,000	0.359×10^{-3}	0.99889
5,555.6	10,000	0.57346	0.69655	55,555.6	100,000	0.239×10^{-3}	0.99918
5,666.7	10,200	0.54877	0.70754	∞	∞	0	1.00000